TRANSPORT OF COAL-TAR DERIVATIVES IN THE PRAIRIE DU CHIEN-JORDAN AQUIFER, ST. LOUIS PARK AREA, MINNESOTA

A Project Proposal

by the

U.S. Geological Survey
St. Paul, Minnesota

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INTRODUCTION

Operation of a coal-tar distillation and wood-preserving plant during 1917-72 in St. Louis Park, a suburb of Minneapolis, Minn., resulted in serious contamination of ground water.

In July 1978, the U.S. Geological Survey, in cooperation with the Minnesota Department of Health, began a two-year project to obtain a detailed understanding of the transport of coal-tar derivatives through the ground-water system in the St. Louis Park area. Hult and Schoenberg (1980) present a summary of the data obtained during the first year of the study and preliminary conceptual models of the mechanisms and pathways of contaminant transport. Hult (1980a) interprets these and additional data in greater detail, and presents the results of preliminary analytical and computer modeling of transport in the Prairie du Chien-Jordan aquifer. Hult (1980b) evaluates the effect of multiaquifer wells on the spread of contaminants between aquifers.

As stated in the project proposal for the first two-year project (December, 1978, p. 2):

"the problem is complex. Design of effective remedial action and realistic predictions of the results of those actions will require much detailed information and a calibrated three-dimensional flow model coupled with a transport model (SWIP). Calibration requires analysis of data from a significant number and range of measurable hydrologic-stress events which, in turn, commonly requires three to five years of record collection to develop a model of known and acceptable accuracy. The first two-year study [MN 79-061] will provide valuable insight into the problem and will aid decisions on probable continuation of the project for at least two more years. Development and application of a calibrated model to evaluate the possible effects of remedial actions proposed by State and local agencies will require extension of this project."

The two-year project now being proposed is in agreement with the timing and purpose of the project foreseen in 1978 and cited in the previous paragraph, but the scope of the project has been narrowed to best meet immediate needs within anticipated funding.

> "However, because of intense local concern, considerable Federal interest, complexity of the problem, and difficulty of effective remedial action, it is anticipated that continued funding will be available. The approach to the problem must therefore balance the immediate needs of the cooperator with the longer-term requirements of a more definitive study." (1978 project proposal, p. 4.)

THE PROBLEM

The major problem is the presence of toxic coal-tar derivatives in water withdrawn by some municipal wells in the area. As early as 1932, the Prairie du Chien-Jordan aquifer, the region's major ground-water resource, contained water with a coal-tar taste at least 3,500 feet from the site. During 1975-80, use of five St. Louis Park municipal wells completed in this aquifer was discontinued because the wells yielded water containing trace amounts of coal-tar compounds, including benzo(a)pyrene, a carcinogen. Each of the five bedrock aquifers in the metropolitan area underlies the site, and each may have been affected to some degree by the contaminants.

The complicated ground-water hydrology, the diverse chemical and physical properties of coal-tar constituents, and the length of time the contaminants have been moving through the ground-water system, have combined to produce a complex distribution of contaminants.

Individual coal-tar compounds differ widely in toxicity and chemical and physical properties. For example, phenol is about 10 million times more soluble in water than benzo(a)pyrene. Differences in solubility cause large variations in the proportion of each chemical that is dissolved into the ground water, remains in a mixture of liquid hydrocarbons, or is sorbed onto geologic materials. The proportions change with chemical concentration, in space, and with time.

Coal-tar derivatives reached the water table by infiltration through the unsaturated zone and at ponds that received surface runoff and process water from the plant. The highest concentrations of contaminants are in the drift beneath and near the site. Parts of this volume of drift contain an undissolved, liquid mixture of many individual coal-tar compounds. In June 1979, a sample of this liquid from a monitoring well completed in the drift at a depth of 50 feet contained 97,000 mg/L total organic carbon. This hydrocarbon fluid has moved vertically downward relative to the direction of ground-water flow because it is denser than water.

Ground water entering the area of the site through the drift is contaminated by partial solution of the hydrocarbon fluids and by release of compounds sorbed on the drift materials. The contaminated water moves laterally to the east and southeast. Water in the drift 4,000 feet from the site contains less than 10 mg/L dissolved organic carbon, but has a distinct "chemical" smell, and contains a large proportion of coal-tar compounds of high solubility relative to compounds of low solubility.

Contaminants entered the uppermost bedrock aquifer, the Platteville aquifer, directly from the drift and have moved at least 7,000 feet from the site. The contaminants reached deeper bedrock aquifers, primarily the Prairie du Chien-Jordan aquifer, through wells that hydraulically connect the aquifers. Coal-tar compounds have moved to a depth of at least 650 feet in the bore of a multi-aquifer well 4,000 feet from the site. Locally, the contaminants have reached the St. Peter aquifer through the Glenwood confining bed and(or) through bedrock valleys where the confining bed has been removed by erosion. In addition, coal-tar has entered the bedrock-aquifer system directly through a spill into a well that was originally drilled to a depth of 909 feet.

The bedrock ground-water flow system is continually adjusting to hydraulic stresses such as ground-water withdrawals and flow through wells that connect more than one aquifer. As these stresses change, the direction and rate of contaminant transport change. Because the upper part of the Prairie du Chien-Jordan

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aquifer is a carbonate rock having fracture and solution-channel permeability and low effective porosity, contaminants can move rapidly through this aquifer. Consequently, the concentration and composition of contaminants in water pumped from individual industrial and municipal wells completed in the Prairie du Chien-Jordan aquifer fluctuates with time.

About 80 percent of ground water withdrawals in the St. Louis Park area are from the Prairie du Chien-Jordan aquifer (Hult 1980a). All the municipal wells that have been shown to be contaminated are completed in this aquifer. Therefore, the project being proposed would focus specifically on the Prairie du Chien-Jordan aquifer.

OBJECTIVES

The objectives of the proposed one-year study are to:

1. Develop the ability to predict contaminant behavior in the Prairie du Chien-Jordan aquifer using a computer model.
2. Preserve continuity in the collection of time-series water-level and pumpage data from all aquifers.
3. Provide for consultation with the U.S. Geological Survey by the cooperators and their consultants.
4. Provide for continued geophysical logging and evaluation of multi-aquifer wells as they are located in the field.
5. Continue collection of chemical data needed to ~~replace~~ refine the understanding of the problem and to calibrate the model. Additional support for chemical analyses will be needed to meet this objective.

The major emphasis in the proposed project is the development of a method for evaluating the effectiveness of measures taken to minimize both the concentration of coal-tar derivatives in municipal wells in the area, and the continued spread of contaminants in the Prairie du Chien-Jordan aquifer. Hult (1980a) has shown that manipulation of withdrawals from industrial and municipal wells, in conjunction with a continued effort to locate, evaluate, and seal multiaquifer wells injecting contaminated water into the aquifer, may be effective in minimizing the concentration of contaminants reaching municipal wells. Preliminary solute-transport computer models of the aquifer that have been developed to date have proven to be a useful tool in evaluating the problem. The proposed project focuses on refining this tool to more adequately reflect actual hydrogeologic conditions.

SCOPE

The proposed project would focus specifically on the Prairie du Chien-Jordan aquifer. However, unless additional support for chemical analyses of water samples is obtained, the proposed project will depend primarily on previous water-quality data, and data which may be obtained by the Minnesota Department of Health during the first 9 months of the project. High priority will be placed on obtaining additional support from Federal, State, and local agencies for chemical analyses. Additional work is needed to (1) establish an intra-laboratory quality-assurance program, (2) define the areal extent of contamination in the aquifer for at least one date, (3) obtain time-series chemical-quality data at critical locations and times with which to attempt calibration of the transport model, and (4) continue identifying additional contaminant compounds in the aquifer which are significant with respect to transport processes or are considered by the cooperators to pose a risk to human health.

Multiaquifer wells are the major pathways of contaminant transport to the Prairie du Chien-Jordan aquifer identified to date (Hult, 1980a; 1980b). Continuing evaluation of multiaquifer wells, in conjunction with the well-abandonment program of the MDH, is within the scope of the proposed project.

Evaluation of other pathways of contaminant transport to the aquifer will depend on previously collected data. Specifically, coal tar entered the Prairie du Chien-Jordan aquifer through a deep well on the site (well W23; "Hinckley well on the site"). The coal tar in the well may be a continuing, significant source of contaminants to the aquifer (Hult, 1978; 1979a; 1979b; 1980a; 1980b; Hult and Schoenberg, 1980). Specific steps needed to evaluate and minimize impact of this source have been suggested to the Minnesota Department of Health. These steps would require additional funding.

In addition, contaminants may be entering the Prairie du Chien-Jordan through the overlying St. Peter aquifer. The mass of contaminants now entering the aquifer through this pathway appears to be small compared to that entering through multiaquifer wells (Hult, 1980a). Installation of additional monitoring wells would be needed to further test this hypothesis.

Continued detailed evaluation of the drift, Platteville, St. Peter, Ironton-Galesville, and Mount Simon-Hinckley aquifers is beyond the scope of the proposed project. The scope of the proposed project could be expanded to include additional work over a longer period of time if funding becomes available. The relationship between past projects, the proposed project, and possible future projects is shown in table 1.

Table 1.--Relationship of proposed project to past and possible future projects

USGS project	Dates	Principal objectives	Related activities by other agencies	USGS publications
Project	July 1978-June 1979	Develop a detailed understanding of the transport of coal-tar derivatives through aquifers in the St. Louis Park area.	Well abandonment program by MDH	WRI, Hult & Schoenberg, 1980
MN-79-061	July 1979-Sept. 1980			WRI, Hult, 1980a; 1980b
Proposed project	Oct. 1980-Sept. 1982	Refine transport model of the Prairie du Chien-Jordan aquifer.	Design of proposed remedial action by MDH consultant	WRI
Possible future projects (MDH)	Oct. 1981-Sept. 1982	Continue collection of time-series data in all aquifers. If additional funding becomes available, and contingent on availability of project chief for project work, refine understanding of transport processes and models of the drift, Platteville, St. Peter, Tronton-Galesville, and/or) Mount Simon-Hinckley aquifers.	Implementation of remedial action by State and local agencies	WRI
	Oct. 1982-Sept. 1983	Attempt calibration of models based on four years of time-series chemical data and response of the groundwater system to remedial action. Design a long-term monitoring strategy to monitor and evaluate the effectiveness of remedial measures.		Final report, USGS Professional Paper

TIME AND COST SCHEDULE

The costs for this proposed project (Fed FY 81 and 82) will be shared by the Minnesota Department of Health, City of St. Louis Park, Minnesota Pollution Control Agency, U.S. Environmental Protection Agency, and U.S. Geological Survey. Development of the computer model of the Prairie du chien-Jordan aquifer will be completed during FY 81. A report in the USGS Water-Resources Investigations series will be prepared, reviewed, and published during FY 82. The Minnesota Department of Health will provide laboratory water-quality analyses, down-hole television camera surveys, and prepare selected wells for geophysical logging in the amount of $10,000 in lieu of funds which will be matched by the Geological Survey. The City of St. Louis Park will assist in monitoring pumpage, water levels, and water quality in municipal wells, and will provide landscaping of monitoring-well sites in the amount of $5,000 in lieu of funds which will be matched by the Geological Survey. Proposed funding is as follows.

Proposed funding in FY 1981—Model development

	Cash	Services	USGS Match	WOTSC[1]	DOTSC[2]	Net cash
EPA.....	$50,000	$ —(5)	$ —	$ 7,250	$10,000	$32,750
SLP.....	5,000	5,000[3]	10,000	1,800	3,000	10,350
MPCA.....	5,000	—	5,000	900	2,000	7,100
MDH.....	5,000	10,000[4]	15,000	2,700	4,000	13,300
Totals	65,000	15,000	30,000	12,650	19,000	63,500

[1] EPA = 14.5 percent; others at 9 percent.

[2] 20 percent of all cash and matching funds; 0 percent on direct services.

[3] Assistance in monitoring municipal wells, and well-site landscaping.

[4] For camera logging of wells and analysis of samples collected by the USGS.

(5) Value of possible water-quality analyses has not yet been determined.

Itemized expenditures of net cash, FY 1981

Hydrologist GS-11.....	$24,600
Hydrologic technician GS-6.....	13,900
Computer (50 runs at $200 and 100 runs at $40).....	14,000
Equipment purchase and rental.....	6,000
Travel (includes $1,500 for training).....	2,000
University of Minnesota (adsorption coefficients).....	3,000
TOTAL	63,500

Proposed Funding in FY 1982—Report processing and publication

Hydrologist (1/2-time)	$ 13,300
Typing, drafting, reproduction	3,200
DOTSC	6,250
WOTSC	2,250
Total	$ 25,000

Project costs in FY 82 would be shared equally by the U.S. Geological Survey and the cooperators.

REFERENCES

Hult, M. F., 1978, Letter to R. L. Wade: Dated November 16, 1978.

____1979a, Letter to R. L. Wade: Dated February 6, 1979.

____1979b, Presentation to joint meeting of Twin City Geologists and Minnesota Section of the American Water Resources Association: April 26, 1979, St. Paul, Minnesota.

____1980a, Assessment of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Water-Resources Investigations 80-___. (In preparation.)

____1980b, Effect of multiaquifer wells on transport of contaminants, southeast Minnesota: U.S. Geological Survey Water-Resources Investigations 80-___. (In preparation.)

Hult M. F., and Schoenberg, M. E., 1980, Preliminary evaluation of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota. U.S. Geological Survey Water-Resources Investigations 80-___. (In review.)

Prairie du Chien - Jordan aquifer

1. USGS Prairie du Chien - Jordan Aquifer Project

Objectives are to (1) develop the ability to predict containment movement in the Prairie du Chien - Jordan aquifer, (2) preserve continuity in the collection of chemical and hydrologic data, (3) provide for consultation with the US Geological Survey by State and local agencies and their consultants, and (4) provide for continual geophysical logging and evaluations of multiaquifer wells as they are located in the field. See "Transport of Coal-Tar Derivatives in the Prairie du Chien-Jordan Aquifer, St. Louis Park Area, Minnesota", dated August, 1980.

Dates: Federal FY 81 (10/80 to 9/81).

Cash. $110,000. See Attachment 1-A.

Services: See Attachment 1-A.

Funding and Participation:

	Funded By	Performed By
MPCA	$ 5,000.	
MDH	$ 15,000.	Yes
AG		
SLP	$ 10,000	Yes
USGS	$ 30,000.	Yes
EPA	$ 50,000?	

LAC Request: $ None.

Other Sources of Funding, including '81 Legislative Session:
No additional funding needed.

Dates: FY 82 (10/81 to 9/82).

Net Cash: $ 25,000. See Attachment 1-B.

Sources of Funding: USGS - $12,000; others undecided.

Prairie du Chien - Jordan Aquifer, cont'd.

2. Hickok and Associates: Design of a set of proposed remedial actions for soil and ground water contamination.

Dates: 7/1/80 - 10/1/81

Cash: $120,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH	$ 120,000.	Hickok & Assoc.
AG		
SLP		
USGS		
EPA		

LAC Request: None.

Other Sources of Funding, including '81 Legislative Session:
No additional funding needed.

Dates: None - task to be completed in '81.

Cash:

Sources of Funding:

3. Prairie du Chien - Jordan Test Well

Initially evaluate the significance of coal tar known to be in and around Well W23 as it contributes to the contamination of the Prairie du Chien - Jordan aquifer. Install a test well, obtain cores, chemically analyze samples, and install permanent pumping facilities. Preserve samples.

The USGS study has shown that this well may have been a significant source of contaminants to the aquifer.

This task will support the litigation effort, as well as the design of remedial action by Hickok and Associates.

This well is located on the former site of Reilly Tar in St. Louis Park. The site is now owned by the St. Louis Park Housing Authority.

Dates: 6 months to accomplish.

Cash: $61,000.

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes
AG		
SLP	?	
USGS		Yes
EPA		

LAC Request: $ 61,000.

Other Sources of Funding, including '81 Legislative Session:
With funding by the LAC, no further funding will be needed for this task.

Dates: None - task to be completed in '81.

Cash:

Sources of Funding:

4. Sampling and Analyses of Water

This is needed to establish the magnitude of contamination in the major aquifer in the Metropolitan area. These analyses will include constituents recently identified as hazardous, as well as indicate locations where additional monitoring of municipal wells may be requested by the MDH to protect the public health. This work is needed to identify indicator parameters which will be useful in reducing the costs of future monitoring. Work by the USGS and MDH has shown that the contaminants are moving rapidly through the aquifer and that concentrations at individual municipal wells change rapidly.

Dates: FY 81 (10/80 - 6/81).

Cash: $45,000.

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes?
AG		
SLP		
USGS		Yes
EPA		

LAC Request: $ 45,000.

Other Sources of Funding, including '81 Legislative Session:
No additional sources of funding are needed, if funding is given by LAC.

Dates: Additional sampling and analyses of water will be ongoing as part of a program that may be presented to the legislature in the normal biennial budget process.

Cash:

Sources of Funding:

5. Installation of 3 monitoring wells

Installation of 3 monitoring wells to monitor the water quality in the Prairie du Chien - Jordan aquifer.

Dates: FY '82 (7/81 - 6/82)

Cash: $45,000 (each well to cost $15,000)

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		
AG		
SLP		
USGS		Yes
EPA		

LAC Request: None.

Other Sources of Funding, including '81 Legislative Session: None in '81.

Dates: 7/81 - 6/82

Cash: $45,000

Sources of Funding: Legislature, USGS

6. Sampling and Analyses of Water

Maintenance of water quality and water level monitoring network in the Drift, Platteville and St. Peter aquifer by the continuing collection of time series data. The information is requested to determine the changes and spread of contamination from present distribution.

Dates: 10/80 - 6/82

Cash: $35,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes?
AG		
SLP		
USGS		Yes
EPA		

LAC Request: $ 6,000 to fund the first round of sampling to 6/81.

Other Sources of Funding, including '81 Legislative Session: Legislature for $29,000 to complete sampling program by 6/82.

Dates: Funding of $29,000 for the period from 7/81 to 6/82 would be based on legislative action taken in the '81 session, as noted above.

Cash:

Sources of Funding: Legislature, USGS

7. Installation of soil test holes and monitoring wells:

Installation of soil test holes and monitoring wells to monitor the water quality in the Drift (soil test holes), Platteville (4 wells), and St. Peter (4 wells), aquifers. The test holes will be useful for specifically locating the distribution of the bedrock valley and the wells will be placed to critically evaluate the extent and magnitude of contaminant movement via the bedrock valley into the St. Peter.

Dates: 7/81 - 6/82

Cash: $30,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		
AG		
SLP		
USGS		Yes
EPA		

LAC Request: None.

Other Sources of Funding, including '81 Legislative Session:

Dates: Funds will be requested from the legislature in the next session to implement this program.

Cash:

Sources of Funding: Legislature, USGS.

8. Evaluation of 40 soil cores

Chemical evaluation of cores to evaluate the significance of coal tar absorbed on aquifer material as a continued source of contamination. Major cores have already been collected to answer specific questions. Continued analysis of cores by newly developed techniques will be used.

Dates: FY '81 (10/80 - 6/81)

Cash: $20,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		
AG		
SLP		
USGS		Yes
EPA		

LAC Request: $ 3,000.

Other Sources of Funding, including '81 Legislative Session: $17,000. Cost estimates can be refined after initial work is completed.

Dates: It is anticipated that additional cores will be taken and analyzed

Cash: No estimate available now.

Sources of Funding: Legislature, USGS

9. Pumping Test

Implementation of a major, full-scale pumping test in the Platteville aquifer. This is necessary for effective design of a barrier well system and for assessing possible subsidence problems. This project would include installation of monitoring wells, water level recorders, and chemical analyses of discharge. The pumping test is critical to the design of an effective remedial effort.

MPCA needs to determine appropriate regulatory constraints.

Dates: 10/80 - 6/81

Cash: $10,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		(Hickok & Assoc.)
AG		
SLP		
USGS		Yes
EPA		

LAC Request: $ 10,000 .

Other Sources of Funding, including '81 Legislative Session:
With full funding by LAC, no further funding will be needed for this task.

Dates:

Cash:

Sources of Funding:

10. Preservation of Samples

Need to store samples (existing and future) in glass ampules in order to preserve the samples for re-analysis, to validate original analysis, and to preserve evidence for litigation.

Dates: 1 month for the preservation of past samples. Concurrent with sample collection through June of '81.

Cash:

Services:

Funding and Participation:

	Funded by	Performed By
MPCA		
MDH		Yes
AG		
SLP		
USGS		
EPA		

LAC Request: $ 5,000 (preliminary estimate)

Other Sources of Funding, including '81 Legislative Session:
With full LAC funding, no additional funding will be required.

Dates: FY '82 (7/81 - 6/82) Continuing need to preserve samples as they are collected.

Cash: No estimate of additional cost for the preservation of samples.

Sources of Funding:

Preservation and Analyses of Samples cont'd.

11. Quality Assurance Program

To evaluate the adequacy of lab methods, conduct a quality assurance program, particularly for organics. Participation of 3 or more labs, including USGS, MDH and possibly EPA and ERT (consultants to Reilly Tar). Analysis of 6 field samples, with standards prepared for use of the participating labs.

This information is helpful in establishing the repeatability and accuracy of the chemical analyses.

Documentation of the validity of the analyses is needed for technical evaluation of the problem, monitoring of municipal water supplies, and supporting the litigation.

Dates: 3 months

Cash: $12,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes
AG		
SLP		
USGS		Yes
EPA		Yes

LAC Request: $ 12,000 .

Other Sources of Funding, including '81 Legislative Session:
With LAC funding, no additional funding is necessary.

Dates:

Cash:

Sources of Funding:

12. Minn. Dept. of Health Lab

To assure compatability of the results of past and future chemical analyses, particularly for PAH compounds, the MDH Lab should continue to do chemical analyses done by high performance liquid chromotography on extracts prepared by outside labs. (See related discussion outlined in Task 4 on page 4.)

Dates: Ongoing

Cash: $5,000

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes
AG		
SLP		
USGS		
EPA		

LAC Request: $ 5,000.

Other Sources of Funding, including '81 Legislative Session:
This is a continuing need that will require further funding.

Dates:

Cash:

Sources of Funding:

Preservation and Analyses of Samples cont'd.

13. Selection of Indicator Parameters

Based on the work outlined in Task 4, indicator parameters may be identified which will allow the design of a more efficient monitoring program.

Dates:

Cash: None

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes
AG		
SLP		
USGS		Yes
EPA		Yes

LAC Request: None.

Other Sources of Funding, including '81 Legislative Session:

Dates:

Cash:

Sources of Funding:

14. Well Abandonment

To abate the spread of contamination through multi-aquifer wells, locate evaluate, sample and seal or case multi-aquifer wells. (See LAC Request, dated October 1, 1980.)

Dates: 10/80 - 6/81

Cash: $29,640 (includes $18,540 to locate and evaluate the Monitor Drill Well, $1,000 to locate the Strom Block Co. Well). Does not include the $10,000 needed to evaluate the Minnesota Sugar Beet Well and the $5,000 to evaluate and seal the Rice Sand and Gravel Well - both located on St. Louis Park Housing Authority property.

Services:

Funding and Participation:

	Funded By	Performed By
MPCA		
MDH		Yes
AG		
SLP		
USGS		
EPA		

LAC Request: $ 29,640 .

Other Sources of Funding, including '81 Legislative Session:

Dates: Additional well abandonment efforts will be developed into a program that may be presented to the legislature in the normal biennial budget process.

Cash:

Sources of Funding: